HINTS ON SANITARY REFORM

WITH

A PLAN

FOR THE DISPOSAL OF THE

SEWAGE AND DEBRIS OF GLASGOW,

ITS CONVERSION INTO ARTIFICIAL GUANO,

AND THE

PURIFICATION OF THE CLYDE.

BY

JAMES GRAY M.D.,

AND

ROBERT BALDIE, ARCHITECT, I.A.,

GLASGOW.

GLASGOW: JAMES CAIRNS & CO., 35 GORDON STREET.

MDCCCLXX.

PLAN

GLASGOW SEWERAGE.

Plan shewing lines of Conduit & other Works proposed by Dr. Gray & Mr. Baldie. December 1869.

SCALE FOR HORIZONTALS. Miles.

SCALE FOR VERTICALS. Feet.

DUNBARTON.

GLASGOW

DUMBARTON

BOWLING.

OLD KILPATRICK.

DUNTOCHAR.

NEW KILPATRICK.

DALMUIR.

RAILWAY.

FORTH AND CLYDE CANAL.

CLAYDENS AND DUMBARTON ROAD.

LINE OF SEWAGE CONDUIT.

LINE OF SEWAGE CONDUIT GOVAN.

RENFREW.

RIVER CLYDE.

GLASGOW AND RENFREW ROAD.

GREAT WESTERN ROAD.

MARYHILL.

HILLHEAD.

PARTICK.

GLASGOW.

GLASGOW AND PAISLEY JOINT RAILWAY.

GLASGOW AND PAISLEY ROAD.

GLASGOW PAISLEY AND ARROSSAN CANAL.

PAISLEY.

JOHNSTONE.

RUTHERGLEN

SECTIONS

NORTH SIDE.

SOUTH SIDE.

James Gray M.D.

Robert Baldie J.A.

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THE SEWAGE QUESTION.

Paper, as Read by Dr. Gray before the Sanitary and Economic Section of the Glasgow Philosophical Society, with Plan by Mr Baldie, Architect.
27th December, 1869.

Mr President and Gentlemen,

I have great pleasure in being here to-night, in accordance with your desire, to lay before you a Plan for disposing of the Sewage of Glasgow.

This subject has for many years engaged my attention; and having carefully considered the various modes which have been recommended for the removal of the Sewage, some months ago I called on Mr Baldie, Architect, Bath Street, and consulted him as to a plan for the removal of the Sewage; and the plan or scheme now placed before you is the joint result of our labours.

The Sewage Question is undoubtedly of the highest importance, both from considerations of public health and national economy; and, fortunately, the investigation of the subject by scientific and technical societies, Parliamentary committees, &c., have furnished such a mass of valuable evidence, in the shape of committee reports, scientific experiments, treatises, and so forth, that we are now in a most favourable position for forming a correct opinion on this question in all its bearings.

But, before entering upon that portion of the subject which we have more immediately under consideration at this time, perhaps we may be allowed to offer a few remarks on sanitary improvements. The importance of sanitary laws seems to have been understood from the earliest dawn of civilisation, as we learn from the records of antiquity; and in tracing the history of ancient nations it is

shewn that primitive legislators were as fully alive to the necessity of a sanitary system for the interests of public health as in our own day. In confirmation of this fact, Scripture sets forth the Mosaic ordinance, which was rigorously enforced amongst the Hebrews by their great Lawgiver. The ancient Romans had their famous Cloaca Maxima, extensive remnants of which have been preserved, and still serve the original purpose to our days. In the middle ages, however, when the ruling passions were religion and warfare, every institution that bore any relation to domestic comfort and happiness fell away, consequently sanitary regulations were totally impeded—a folly which was dearly paid for, in the frequent and awful visitations of Black Death, and other fearful diseases. Coming down to our own times, it cannot be denied that modern civilisation has effected many wonderful improvements in our towns and cities. But, in this age of progress, we think we might have even yet a *more perfect sanitary system*; at least, one or two amendments could be made with advantage to us all. There can be no doubt or question that the enormous death-rate of our own city is in a great measure owing to the imperfect sanitary condition of its poorer districts. The sanitary reports that have recently appeared in the columns of the daily papers fully corroborate this fact, for if only the one-half of what is told there be true, it would be sufficient to account for the mortality that prevails in those quarters. We all know very well that dirt and filth are opposed to health; and just in proportion as *Hygienic Laws* are slighted, does disease make head, and gain a surer footing. In fact, filth and disease go in company. Filth pollutes the atmosphere, and sets deadly agencies to work, from which there is no escape. The course may be gradual, but it is no less certain. If you throw a fish into an impure stream, it dies; and a poisoned atmosphere operates in the same manner upon human life, although the effect is longer of shewing itself. It appears there are two modes by which a polluted atmosphere affects animal life, viz.:—by direct respiration of the gases generated entering the lungs and the blood; and secondly, by imparting germs of microscopic fungi, and infusoria, which are invariably developed by putrefaction of organic matter. It is clear, therefore, that a polluted atmosphere poisons life; and the miseries which arise out of this evil are neither few nor small. Perhaps that most to be deplored, however, is the entailing of disease upon offspring. Unhealthy parents cannot propagate healthy children, and their progeny are most likely to inherit the curse of an enfeebled constitution when they come into the world.

The great mortality amongst children in the unhealthy districts is an incontestable proof of the evil influences which are at work there. In looking over the death returns for the first quarter of this present year, we find the total under five years amounts to 2332. Before we can hope to mend the present state of matters, we must have a thorough reform of those places in which the humbler classes are compelled to live, and strike at the root of the evil. The pestilential dens that pollute our otherwise fair city, and disgrace its Christian name, must be swept away.

The Dean of Guild has it in his power to order the demolition of unsafe buildings, and Sanitary Officers should have the right to doom those unclean nests, which pollute the very air we breathe, and disseminate the seeds of disease far and wide. It is useless to attempt to improve either the physical or moral condition of the masses so long as we leave them

> "In dens where human souls,
> In beasts' lairs, bestial grow,
> And hand in hand that sister band—
> Vice, Drunkeness, and Woe."

And as it has been well said, "There is perhaps no agent more powerful to debase morals than familiarity with dirt." The constant presence of filth, the difficulty of its removal, or the hopelessness of all attempts for that purpose, will give even to a person of cleanly tastes in a short time dirty habits of dress and person; and the organs of sight and smell becoming blunted, a gradual descent to vulgarity of speech, low manners, indecent exposure, prostitution, and complete moral perdition, is comparatively easy; and there can be no doubt whatever that it is just those Homes referred to which turn out the juvenile thieves and other vicious characters, which are the pests of society. What can be expected from beings reared amid filth, and squalor, and misery? How is it possible to retain freshness, and purity, and innocence, in polluted dens, such as are to be found in the Havannah and similar districts? "Who can bring a clean thing out of an unclean?" It may be said that the inhabitants of the slums are in a great measure to blame for the condition they are in, and to some extent this is true. But we must remember that they have never been *educated* up to a high standard of *cleanliness*. Their earliest experience has been filth and corruption, and they have been reared in an atmosphere of moral pollution from the first

dawn of life. The first step, therefore, in the work of Reform must be to improve their *material* condition. As a writer on the other side of the Atlantic remarks, "A vital reform of the inhabitants of the slums must begin outwardly, and landlords should be compelled to give habitable, healthful dwellings, at the same price they charge for poison dens, ruinous to body and soul." Let landlords co-operate with Sanitary Officers in providing the means for carrying out sanitary regulations, and let *them* be responsible for the sanitary condition of their houses in so far as it shall be deemed practicable. Then the fault will be *theirs* who neglect to fulfil the Law's requirements, and compulsory measures may be taken to enforce them. At present the working classes are very ill provided with household requirements, and many houses for which high rents are taken are utterly destitute of the necessaries which common decency requires. The next step, however, must be to Educate, and one of the most effectual ways is by *example.* We think it would be well if Schools took up a Sanitary Branch of Education, and pressed its importance upon the young. "Prevention is better than cure;" and it is when habits are forming, and the mind is plastic, that lasting impressions are made for good or evil. It would be an easy matter for writers of school books to insert lessons on this subject in a pleasing form, so that the importance of cleanliness in regard to health might be thoroughly understood by the rising generation. "Line upon line, precept upon precept," until the royal truth becomes an established principle in every household, "Cleanliness is next to godliness." Further, in carrying out sanitary improvements, we would suggest that instead of scavengers, there should be a Sanitary Brigade appointed for each district, with superior officers, whose duty it should be to see that the regulations are strictly carried out—the Officers to be men of education and practical experience, qualified to direct with skill and intelligence the work carried on under their supervision. A course of training might be given by means of lectures, essays, &c., open to all in the Brigade.

But we must pass on from this branch of the subject, and in conclusion will only ask your permission to make one or two suggestions, which we think may help to facilitate sanitary improvements. First: It would greatly tend to keep houses in closely populated districts healthy, if landlords were to whitewash the inside walls, say twice a year, with carbolite of lime. Secondly: A plentiful supply of water and proper privy accommodation should in all cases be afforded, to ensure decency and decorum, and, we may add, for the protection of virtue.

Thirdly: The causeway, in closes and courts, should have a layer or coating of asphalte over it to prevent filth entering between the stones, *which is very essential*, as the matter collected by this means ferments, and thus prepares a field for the reception of epidemics. Fourthly: The present system of ashpits should be done away with, and moveable ones, made of iron, substituted. Also, depots should be placed in each district for the reception of the manure, which would command a price according to its quality. The consideration of payment would induce the poor to clear out the hidden corners, and from motives of worldly selfishness, those who wallow in filth will become voluntary agents of cleanliness. And now, returning to the chief point with us at present, we shall as briefly as possible take up the Sewage Question in connection with our plan.

As many as twenty different schemes, many of which possess the maturity of plans, have been projected within these ten years for disposing of the Sewage of Glasgow. Two schemes a year is a rate of production which proves the fecundity of the inventive talent of our townsmen, and they suggest also the sincere purpose which must animate many minds to endeavour to get well rid of a formidable and a growing evil. We must, in one way or other, remove our Sewage from our neighbourhood, as it comes to be formed. A regard for the lives, health, and comfort of the community demands this, and we have no alternative but to make, sooner or later, the attempt; and the question that presses is, not the propriety of some decision to this end, for upon that we are all agreed, but for more than the twentieth time has the practical question recurred, "How is this work to be done?"

The various plans proposed are so many definite answers to this urgent enquiry. That these plans have very different merits, we are all of course prepared to admit; but when so many intelligent, studious, and professional minds have already been exercised upon some problem, it is not too much to assume that the elements of some effective plan may be deduced. In what we are about to submit to this honourable Association we confess that we owe obligations to our predecessors, but we at the same time lay claim to some originality of design.

Our scheme divides itself mechanically into two parts, which are severally, "Sewage Transportation" and "Sewage Utilization." These parts are in theory independent of each other—they do not involve each other as to method; nor need they be held as financially responsible for each other. At the same time,

if separately successful, their combination should render the whole scheme, not a pecuniary burden, but a profit to the community.

We proceed upon the assumption that "Sewage Transportation" should be spontaneous, or self-acting, and that it should comprehend together sewage proper and rainfall. This continued and compound flood has been computed at a maximum of 74 million gallons per day, and, allowing for the growth of the city, of 106 million gallons twenty years hence. Our present sewage, independently of rainfall, is daily about 35 million gallons; while the rainfall, taken over the area of the city, may, on occasions, more than double that amount. Of course, where conduits are concerned, the maximum rate of flow sets the scale of size for such artificial water-ways. We further assume that we should not attempt to manipulate this stream, which is really larger than the flow of the Clyde in dry weather. The run varies considerably in volume from day to day, and in drought it does not discharge more than 50 million gallons daily, with probably 300 or 400 times that amount when in flood. We, therefore, propose to get rid of our sewage and rainfall together by gravitation, and that in the general direction of the river channel, regarding it as the proper and natural pathway for the contaminated flood to the ocean. For this purpose we would employ the well-known plan of intercepting sewers, running roughly parallel to the river, on either side, until a point is attained down stream, where a new plan of sewage utilization will be introduced, and the filtered and purified sewage water will soon meet in brackish water with the great purifier, the sea. But more of this hereafter.

We shall, at the outset, be met by the objection that the elevation of Glasgow above the sea level is so small, and the consequent flow of the Clyde so very sluggish, that these side conduits, running, as they must do, parallel to the river bottom, will soon get silted up, and the scheme thereby be rendered abortive in a very short time. To this we reply that the deepening of the Clyde has deprived us of the observational convenience of judging correctly of the speed of the flow of the river, and we are left for this matter to hydraulic theory. Moreover, the Clyde is a tidal river, and that fact, under any circumstances, would conflict with observation, and render the river channel an unfit pathway for cleaning away sewage or any impurities, liquid or solid, that might be thrown into it. Experiment has shown that when the natural volume of the river was small, wooden floats would not, between conflicting tide and river flow, reach

Govan Ferry in less than a week, nor the mouth of the Cart in less than a fortnight—the distance being respectively $2\frac{1}{2}$ miles and 6 miles—and that they would take consequently more than a month in getting down the river as far as Dumbarton.

As indicating the influence of the tide, it has been anticipated the removal of the weir above Hutchesontown Bridge will have the effect of carrying some of the Sewage still higher up the river. If we take our harbour, now a mile and a-half long, 100 yards wide, and 24 feet deep at high water, and if we keep in view that the river all the way down to Dumbarton is of this depth, it is easy to perceive that fifty million gallons poured by the Clyde—*plus* thirty-five million gallons of sewage—to the channel, can have no appreciable force to move this vast body of water in the harbour and below it. The whole mass of fluid is really as stagnant as a canal, and the deeper the river and harbour the more stagnant it becomes. In floods, when some proportion exists between the water at rest and the water in motion, an impulse is given to the latter calculated to scour the harbour and river in some degree, but as this seldom happens, the force of the normal current of the river is insufficient, as the experiments with wooden floats so well show. Nothing, then, can be argued from the river flow as to what the unimpeded Sewage flow in separate conduits running along the banks of the river may be.

It may be fairly estimated that intercepting Sewers, proportioned to their contributions respectively towards the gross quantity of fluid to be sent through them, will give a velocity to the current sufficient to prevent all deposit. With a fall of 20 inches to the mile, the minimum flow will never be less than $1\frac{3}{4}$ feet per second, or $1\frac{1}{5}$ miles per hour; and when half full, $2\frac{1}{2}$ feet per second, or $1\frac{7}{10}$ miles per hour—a velocity which should give abundance of scour through the tubes.

The plan we propose is the forming two large intercepting Sewers, which run one on each side of the Clyde, and receive in their course the total Sewage of the city, including its rainfall. One commanding principle of this plan is to interfere as little as possible with the existing Sewerage of the city, and *not at all, in any way,* with the domestic facilities of the citizens. The water-closet system we regard as fixed and irremovable, and we incorporate it in this scheme, as an essential of it, when the fertilizing properties of the resulting sewage manure are kept in view. The Sewers run as nearly as possible parallel

to the river, and, where practicable, along its banks, so as to secure to the utmost the advantage of the watershed of the city, or its gravitation flow. Where the Sewers diverge from this line, particular obstacles intervene, or important purposes have to be served, causing the departure from what would otherwise be the most desirable route for these main conduits.

The North-side Sewer takes its departure from, or near, the Springfield Printworks, Dalmarnock Road, along and below which road it passes for a short distance, whence it strikes directly west Newhall Street to the Clyde. In this stretch the Sewer captures the Sewage of Bridgeton on the north, and Barrowfield Works, &c., on the south. From Newhall Street, the Sewer strikes through Glasgow Green, cutting the Green obliquely, and, passing between Nelson's Monument and the river, reaches the Court-Houses at the bottom of Saltmarket Street. Into these two sections of the great tube the whole sewage of the city east of Saltmarket Street and High Street passes. The Sewer proceeds from the Court-Houses close by the river along Clyde Street and Broomielaw, to Finnieston Quay. Here a considerable divergence from the line of the Sewer takes place to enable the Sewer easily to pass to the North side, clear of the proposed wet dock at Stobcross, whence it passes on in nearly a straight line to where a convenient crossing of the Kelvin can be effected. In this long stretch of about two miles and a half —from the Court-Houses to the Kelvin—the body bulk of the Sewage and rain-fall of the North side of the city would come into the intercepting Sewer. The crossing below the Kelvin is effected at a point where the Sewer may, without any sudden flexure or bend, pass round the north end of Messrs Tod & M'Gregor's Graving Dock: other obstructions are encountered in this locality, and a little beyond, requiring a moderate departure from the straight line, until Dumbarton Road is reached. The Sewer now runs for about a mile along the side of this road to Whiteinch Burn, crossing below which, it diverges from the line of road, owing to the sinuosities of the latter, but again nears the Dumbarton Road about a quarter of a mile beyond Scotstown House. In this stretch of about two miles and a-half the Sewage of Hillhead, Dowanhill, and Partick, are received from the north, and of the growing suburbs of Whiteinch, Merklands, and Meadowside, to the south of the Sewer line. From the west of Scotstown House to Yoker Burn the course is parallel to, and close by, Dumbarton Road, where, for about a mile, the Sewage of sundry growing populations is taken into the common

channel of transport. Passing beneath Yoker Burn, the route leads on to the Forth and Cart Junction Canal, under the bed of which it passes to its terminus, opposite Newshot Island. Here a pumping or lifting station is to be erected; but more of that hereafter.

This North-side intercepting Sewer is about nine miles long, and varies in diameter, increasing as it proceeds, from four feet to seven feet six inches, depending on the incursion of increasing quantities of Sewage, and of possible sudden enlargement of the volume of the liquid from rainfall. The gradient or slope of the Sewer is, for the first two and a-half miles, about four feet per mile; for the next three miles, about one foot per mile; and for the remainder of the distance, about twenty inches to the mile. It is evident that a huge conduit of this kind, to pass through a built city, must in its course be influenced in direction by that commanding fact. In every instance where departure from the direct line has to take place, the bend has been made as little abrupt as possible, so as not to impede the flow, or to cause the solid materials which may be in suspension in the Sewage, to silt. The same necessity, of course, governs the position of the Sewer in the vertical plane; it must not dip at any point, but preserve a uniform slope in its descent. In the satisfaction of this requirement a difficulty was met in the too near approach of the bed of the Kelvin to the required level of the bed of the sewer or conduit. To deepen the Kelvin would, of course, be of no use, as the sewer could not be depressed beyond its own proper depth at any one point; and to present the full diameter of the sewer to the river flow would lead to other complications. As a remedy, the sewer at this spot, in crossing the Kelvin, will have to be trifurcated or directed into three flat diverging branches, so as to take up the full duty of the undivided sewer; and this obstruction once passed, the original cylindrical form of the sewer is restored. About two-thirds of the Sewage of Glasgow would be taken up by this North intercepting Sewer; and when the flood of Sewage has reached its terminus, opposite Newshot Island, it would come under special treatment for the extracting of its manurial properties.

The spot selected is where the Forth and Clyde Canal approaches within 400 yards of the Clyde, and within 100 yards of the Canal bank. Very special reasons, as we shall presently show, have induced us to prefer this site for the completion of our proposed scheme of sewage utilization. Here the sewer at its terminus is to expand into a large tank, into which for the instant the arriving

flood is to be poured, and from which tank, or pond, we propose by some mechanical means to lift the sewage a height of about 16 feet for filtration. The filtering vessels are to be two or more tanks, and to be used alternately, or while one filtering tank is being discharged of its solid residuum, another is being charged with the sewage to be filtered. The filtrate will pass through and flow into the Clyde nearly pure; the solid filtrant will be retained as a manure for further manipulation. But to return: here we have about a million and a half gallons of sewage to be raised a height of say 18 feet, for every hour of the 24—and a very important question is, how can this be best and most economically done? Two means are suggested for the purpose, and those are—steam power and water power; and two processes also, viz., pump action, and lifting wheel action. It is very obvious that steam may be employed to work pumps or to drive a lifting wheel; and if steam came to be used we should prefer its connection with such wheels as would at first raise at least thirty million gallons a day on the North Side, and as the volume increased, according to the increase of the city, the required number of wheels, with additional tanks, could be added.

The most economical power is water; and water operating on an overshot wheel, should be employed to propel the lifting wheels to be used in the work. Two chief reasons induced us to select the site referred to for the proposed scheme of sewage utilization, viz., the hope of procuring from the neighbouring district of country, where a reservoir might be constructed, at a proper elevation, a head of water of sufficient force to perform the entire duty connected with the proposed works, and also, the advantage of having the canal near for the import of filtering materials, coal, &c., and the export of the manufactured manure, and also its proximity to the Glasgow and Helensburgh Railway.

It is obvious that the employment of water power in the manner and for the purpose indicated has many advantages. It will prove vastly cheaper in all ways, and as effective as steam. It can be made as good as self-acting, and can go on day and night. The only interruption it may have to encounter is from temporary frosts, but these are so seldom of long duration that they may be dropped out of sight as of little account.

To return for a second or two to the main conduit. Along the entire course of the intercepting sewers, on both sides of the Clyde, overflows to meet any sudden and excessive rainfall will be constructed at parts where the main sewers are accessible, by the smaller feeders leading from the City. This excess will

pass at once to the river, and being only surface water, it will be innocuous. The intercepting sewers, or main conduits, as we have already hinted, will be large enough to capture the average rainfall. Our rainfall in Glasgow, according to statistics, varies considerably from year to year, and our arrangements will be adapted to this change; but sudden and excessive local and seasonal falls have to be dealt with exceptionally and in the manner we propose. Our arrangements are also adapted to the prospective increase of the city.

The South-side intercepting sewer will be about 8½ miles long, with an enlarging diameter of 3 feet at its commencement to 5½ feet. Its east-end starting point is at or near Polmadie Burn and near Shawfield Print Works. It approaches the Clyde obliquely at the east-end of Caledonia Road, whence it strikes through a plot of but partially occupied ground to South Wellington Street, which it crosses at its junction with Govan Street, along which, and through Malta Street, &c., it passes on to Windmillcroft. By far the greater portion of the South-side sewage would be intercepted by this portion of the main sewer, which, from its commencement at Polmadie Burn, is about two miles long.

The lower ends of the streets that run down to the river, and that are cut at right angles by the main sewer line, and also the streets that lie parallel to that line and between it and the river, such as Oxford Street, and Clyde, Carlton, and Adelphi Places, will have their sewage sent by a return current into the great intercepting sewer further up. The main sewer must of course be sunk to a level deep enough to induce these streams to flow back into it, and prevent them from falling into the Clyde as they do at present. It may be said here that this arrangement would be pursued with all sewage flows that might exist between the intercepting sewer and the river, they would all be of easy curvatures, be turned back on their original course into the desired channel, and thus keep the river water pure.

From Windmillcroft the sewer following the line of the Govan and Renfrew Road proceeds to and passes Govan, dividing the growing population of this district to the right and left. The line diverges somewhat at, and above, Govan Silk Factory, it returns again to Renfrew Road, and continues along the same line of road till Renfrew is reached. The sewer will now pass close and to the south of Renfrew, and receive the sewage of that thriving town as it proceeds to the Cart, which it crosses immediately above Blythswood Home Farm-house. At this point the sewage of Paisley could be taken with facility, and a little further on

that of Johnstone also. After passing the Cart by an easy curve, the sewer line strikes in obliquely to the Clyde, where it terminates at the east end of Newshot Island. The gradient through the entire length of this sewer is about 20 inches to the mile. At Newshot Island an arrangement for utilizing the sewage in the same manner as on the North side already referred to is adopted, but of course on a smaller scale. That process consists of lifting the liquid sewage by machine power, filtering it, and operating on the residual matter with a view to converting it into a saleable and portable solid manure.

Our plan is seen to resolve itself into two elements, viz., the purification of the river—itself a most important matter and very urgently needed, as we all agree—and the utilization of the sewage, which also is confessedly very important, but still a secondary, enterprise to the former. It is only, however, upon the view of the sewage being utilized that our scheme can be made self-supporting, or pay. Now, we have not the faintest hope that a purely local sale of the sewage as a fertilizer by irrigation will pay, and this plan of its local sale must always attach to the use of the sewage in a liquid and highly diluted form. If a good fertilizer can be procured from this source—and of this we have not the slightest doubt, as we trust by analysis to prove—making that fertilizer a portable article of commerce, a very wide market will be secured for it, and a ready and constant sale. In the schemes for the utilization of the sewage by irrigation, it is obvious that the nutrient properties of the sewage cannot be stored up, and must therefore run to waste or into the sea. Now, by our plan, the elements of plant nutrition are taken out of the sewage at all seasons, and may be stored up for use, and their sale waited for according to the demands of agriculture over the entire kingdom. Our plan, or some kindred plan, is, in our view, the only one which can satisfy the demands of agricultural science. In theory, our duty is to restore to the soil the fertilizers, and the total quantity of them that our agriculture takes from the soil; otherwise, and in the degree we fail of this, we are guilty of causing a culpable waste of invaluable materials indispensable to the promotion of plant life. In this great aspect of this business we contrast our scheme with any of the others that have been proposed.

But supposing for a moment that the manure we propose to make is valueless, and though the contents of the filter had to be put into barges and taken to Lochlong, if the filter is what we say it is, and which we have already by public trial proved—a report of which will be submitted to you—we argue that

our scheme, or plan, will purify the river at less than one-fourth the cost of some of the other schemes proposed.

In regard to the gases generated in the sewer, we propose to put at the necessary distances tubes carried to a certain height, with argand gas burners by which the gases will be burned, and the sulphur which is deposited can be preserved; and to prevent smell at the works, and retain any ammonia that may be evolved, tubes are passed from the roofs of the various houses, and made to pass into hydro-chloric acid. The filter is composed of cinders, peat moss, powdered bricks, and gypsum, which is charged once a fortnight or so, but we do not restrict ourselves to this filter: other materials may be used. The artificial guano is manufactured from the contents of the filter, the carcases of dead animals, from the species of fish unsuitable for human food, and the shell fish (which are found abundantly along the coast), sea weed, and the whole of the street and road sweepings, byre and stable manure, along with human excreta; to which is added ground whinstone, and the refuse of chemical works.

We have now to lay before you the reports and analyses of the filtered water, value of manure, &c. The first report is by Professor Anderson, and is as follows :—

REPORT on the Analysis of a Sample of Purified Water from the Pinkston Burn—the result of an experiment made before the Sanitary Committee.

On the 1st October I received two samples of Water—No. 1 marked "Result of an experiment worked before the Sanitary Committee, at the Pinkston Burn, on Wednesday last, 29th September, 1869"; and No. 2 marked "Water as it flowed from the Burn into the Kelvin."

The samples sent me being small, I have been compelled to restrict my examination within the narrowest limits. I have, therefore, determined only the amount of organic matter, fixed salts, and total solids, together with the quantity of phosphoric acid. The results, expressed in grains per Imperial Gallon, are as follow :—

	No. 1. PURIFIED.	No. 2. IMPURE.
Organic Matter, - - -	6·66	289·29
Fixed Salts, - - -	26·53	393·11
Total Solids, - - - -	33·19	682·40
Phosphoric Acid, - - -	0·21	6·39
Equal Phosphate of Lime, -	0·45	13·96

The sample of Purified Water could not be considered as by any means pure. It was slightly muddy, and had a decided smell, in which that of spirit-distillers' wash and paraffin oil could be distinguished, and it had also a yellow colour. Though the quantity of solid matter is not large, there are sewers in the city which yield, in their normal condition, a water superior to this in quality. It is, however, an immense improvement on the water not submitted to purification, and does not contain more than one-twentieth of the amount of solid matters.

The water from the Pinkston Burn is unusually impure, containing nearly 700 grains of solid matter per gallon. A large part of this consists of spirit-distillers' wash, and sand and clay, apparently brought down by the stream, or possibly stirred up from the bottom in taking the sample.

The greater part of this, I am satisfied, might be removed by filtration alone, and with the production of a fluid not inferior in appearance to the purified sample.

(Signed) THOMAS ANDERSON, P.C.

8th October, 1869.

EXPERIMENTS ON SOME "MINNOWS."

Oct. 9.—One Fish. Water from Pinkston Burn. Put into the water at 10.3 P.M.; died Oct. 9, 11 P.M. Duration of life—57 minutes.

Oct. 9.—Two Fish, put into filtered water, Pinkston Burn, 9.14 P.M. One died at 11 P.M.—duration of life, 1 hour 46 minutes; the other one died 11.30 P.M.—duration of life, 2 hours and 16 minutes.

Oct. 9.—*Two Fish put into Loch Katrine water, 9.40—lived one week.

Oct. 10.—*Two Fish put into one-half filtered from Pinkston Burn and one-half Loch Katrine. Put in at 10 A.M. Duration of life—one week.

Oct. 10.—*Two Fish put into one part filtered Pinkston Burn to three parts Loch Katrine. Put in at 10 A.M. Duration of life—one week.

* NOTE.—These Fish were only kept for the one week, and, when thrown out, were in a healthy state.

Analytical Laboratories, Mechanics' Institution,
38 Bath Street,
Glasgow, 17*th December*, 1869.

Chemical Report of an Analysis of two Samples of "Sewage Manure," marked Nos. 1 and 2, received 2d December, 1869.

These manures were in a finely powdered state, dry, and of a light-brown colour. They are, I understand, prepared by mixing the contents of the ashpits, urinals, slaughter-houses, &c., of the city with the liquid sewage before it passes to the Clyde, and thereafter reducing the mass to powder. In this manner a manurial agent is obtained which contains all the constituents necessary for the plant. The ashpit refuse, besides containing a portion of valuable fertilizing matter, serves as a kind of sponge or bed to absorb the urine and other liquid and semi-solid substances. The urine contains urea and other important nitrogenous bodies, capable of developing ammonia, which is the most valuable constituent of a manure. The products from the slaughter-houses largely contain certain nitrogen compounds, as albumen, fibrin, &c. These also, after a time, are resolved into ammonia. Besides nitrogenous material, urine, excrementitious matters generally, and the refuse of the slaughter-house, contain phosphates, potash, magnesia, and other substances of great value to all kinds of vegetation.

The Analysis of the samples was conducted with much care, and no less than five separate complete determinations were made, to ensure thoroughly reliable results. Many extra experiments were made, to ascertain the true value of the samples as manures. Rain water dissolves out a quantity of nitrogenous matters, so that considerable value must be attached to this fact. Alkaline salts, containing phosphoric acid, and decided traces of potash, are likewise extracted with rain water. The matters insoluble, but which are acted upon by air and moisture in the field, after a time, are organic bodies, phosphate of lime, lime, sulphate and carbonate of lime. In addition to these are earthy matters and sand, which, however, are of no value.

In analysing separate portions of the same sample, slight differences in the proportions of the various constituents were observed, which, no doubt, were due to a want of perfect mixture.

The following results are the mean of five complete analyses made with the Samples Nos. 1 and 2 :—

	No. 1.	No. 2.
Water or moisture,	24·50	21.05
*Organic Matter containing Nitrogenous Substances,	16·31	10·02
†Alkaline Salts containing Phosphoric Acid,	1·71	1·23
Insoluble Sulphate of Lime,	7·30	4·15
Free Lime, Sulphate and Carbonate of Lime,	23·81	21·10
Sand and Earthy Matters,	26·37	42·45
	100·00	100·00
*Containing Nitrogen equal to Ammonia,	1·35	00·45
†Phosphoric Acid in Alkaline Salts equal to Soluble Phosphate of Lime,	2·70	1·42
†Potash in the Alkaline Salts,	*Decided traces.*	Decided traces.

It will be observed from these Analyses that No. 1 is very much richer in fertilizing ingredients than No. 2. The ammonia is three times more abundant, the phosphate of lime twice, and the organic matters one-third more than is present in No. 2.

The money value of these manures is, in my opinion, to be correctly estimated at fifty shillings per ton for No. 1, and twenty-eight shillings for No. 2.

I have before stated that they contain every essential ingredient for the growth and nourishment of the plant; and it is with confidence that I recommend them to farmers and others interested in agricultural pursuits.

(Signed) R. CARTER MOFFAT, P.T.C.A.,
Lecturer on Chemistry, and Analytical Chemist.

In confirmation of what has been already stated, Professor Miller, in his valuable work on Chemistry, states that night soil and urine possess a high value as manure. They are much richer in nitrogenized compounds, and in phosphates, than farm-yard manure; and, indeed, they contain all the saline constituents of the corn and animal food, as well as almost all the nitrogen of the azotised constituents of the food which had been conveyed into the stomach, whether these azotised constituents had been assimilated or not.

The Chinese (adds the learned Professor) have long been aware of the importance of these materials as manure, and they collect and carefully restore to their fields that which we, in the pride of superior civilisation, discharge into

sewers, and wastefully consign to the ocean, after allowing it to accumulate in offensive mud banks, within our tidal rivers, upon the shores of which, by the ebb and flow of the tide, it is alternately exposed to the heat of the sun and to the action of the water, under circumstances the most favourable to its decomposition, in consequence of which it is constantly contaminating the atmosphere of our large towns with its sickening effluvia.

We beg now to submit the following estimate of the probable cost of the proposed sewers, works, &c., and in doing so we wish to remark that the estimates are based on prices received from the firm of A. & J. Faill, contractors, for the sewers; from the firm of Messrs John Norman & Coy., for the engines, lifting wheels, pan mills, &c., &c.; and for the necessary buildings, from data in Mr Baldie's own possession, received recently in the constructing of the new large shipbuilding yard at Linthouse, for the Messrs Stephen :—

Summary of Estimated Cost.—*Dec.*, 1869.

NORTH SIDE.

Main Sewer,	£96,360 0 0		
Branch Sewers, &c.,	5,000 0 0		
Overflows,	2,200 0 0		
Repairing Causeway and Roads,	3,125 0 0		
		£106,685	0 0

BUILDINGS, MACHINERY, AND PLANT.

Buildings of every description,	£30,000 0 0		
Quay Walls,	2,400 0 0		
Engines, Boilers, and Scoop Wheels,	18,000 0 0		
Engines, Boilers, and Pan Mills,	3,000 0 0		
Barges,	6,000 0 0		
Waggons,	2,000 0 0		
Rails, Turntables, &c.,	3,000 0 0		
		£64,400	0 0
Carry Forward,		£171,085	0 0

Brought Forward,		£171,085	0 0

SOUTH SIDE.

Main Sewer,	£67,540 0 0		
Branches, &c.,	1,000 0 0		
Overflows, &c.,	1,760 0 0		
Repairing Causeway, Roads, &c.,	1,875 0 0		
		72,175	0 0

BUILDINGS, MACHINERY, AND PLANT.

Buildings of every description,	£15,000 0 0		
Quay Wall,	2,400 0 0		
Engines, Boilers, and Scoop Wheels,	12,000 0 0		
Engines, Boilers, and Pan Mills,	1,500 0 0		
Rails, Turntables, &c.,	1,500 0 0		
		32,400	0 0
Total Amount for Sewers, Buildings, and Machinery,		£275,660	0 0
Land,		20,000	0 0
Interest on Money during construction of Works, Preliminary, Parliamentary, Law, and Engineering Expenses, say 15 per cent.,		49,209	0 0
		£344,869	0 0

ANNUAL CHARGES.

Interest, at 4 per cent.,	£15,090 0 0		
Annual cost for Machinery, &c.,	2,555 0 0		
Maintenance of Sewers, Working Expenses, and Superintendence,	1,000 0 0		
		£18,645	0 0

Amongst other sanitary advantages which the plan now recommended offers, is—first, the non-contamination of rivers; second, the preventing the escape of deleterious matter into the atmosphere; third, the ensuring, at the least possible expense, the utilization of the whole *debris* of the city; fourth, the preservation

of an immense quantity of valuable manure, the creating profitable employment for a large number of the labouring community, and the thorough completion of a perfect sanitary system.

According to our calculations we shall be able to manufacture above one hundred and twenty thousand tons of artificial guano, the nett profit upon each ton we estimate at 10s., after paying all expenses.

The filter, we are aware, will soon become clogged up; but that is rather in its favour, as the filter is then removed, pulverised, and mixed with the animal manure. The filter has also the advantage of acting as a subsidence pond.

The smell arising from the urinals may be prevented, and the urine at the same time preserved by having wooden tanks filled with cinders previously saturated with sulphuric acid.

Improved machinery will be provided for carrying out the process of grinding, drying, and mixing the manure.

In following out Sanitary Improvements there should be proper washing accommodation provided in the poorer districts. The places fitted up for this purpose would also do for baths, without further cost.

Every dwelling-house should also be properly ventilated, as it is most essential for health that a continual supply of pure air should be admitted.

But, to sum up: the utilization of sewage by the system now recommended would work a peaceful social revolution, both in a sanitary and agricultural point of view. It possesses high advantages; and it may not be too much to predict a golden future for land when the filth of towns is practically transformed into food. What are the great impediments to human happiness but filth, intemperance, and want of food? Filth, the prolific source of disease and death, is as much a foe to human enjoyment, perhaps, as famine, in the long run; and we have seen that it is in our power to make what was hitherto a prolific source of disease and death, a fertilizer of surpassing power, and an agent of happiness. Nay, we have it on scientific authority that immense mines of national wealth might be opened to us by a proper solution of the great sewerage problem. Any way, if the earth—by which alone food is prepared—is made to bring forth abundantly, we may anticipate glorious results.


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